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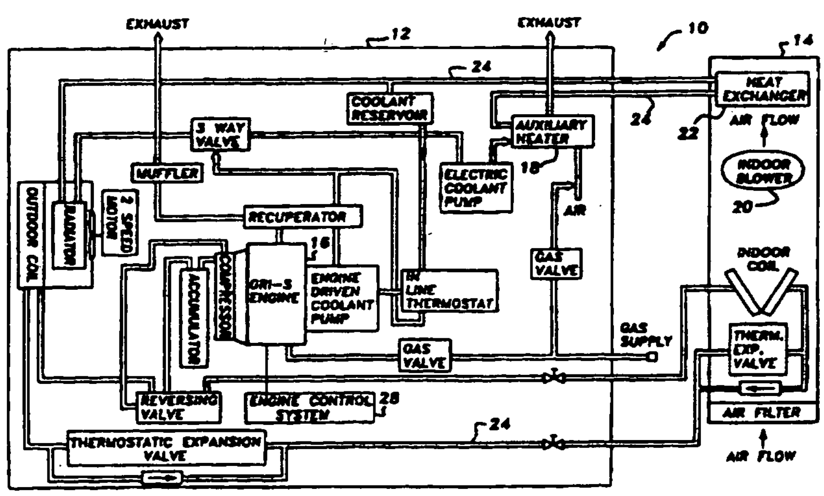

(57) Abstract

A heating and cooling system (10) that provides interfacing between multiple zones in the system (10) and a variable speed heating and/or cooling device, such as a heat pump. The heating and cooling system (10) includes a master zone control circuit (30) that includes a master thermostat (32) for controlling a master zone. The setting of the master thermostat (32) determines whether the heating and cooling system (10) will be in the heating or cooling mode. A plurality of auxiliary zone control circuits (50) include separate auxiliary thermostats (52) for controlling the auxiliary zones. Each of the master control circuit (30) and the auxiliary control circuits (50) provide an output signal whether the particular zone is operating in the currently activated system mode of heating or cooling. An interface device (80) is responsive to all of the output signals from the master control zone and the auxiliary control zones so as to determine which of the zones has the highest demand for heating or cooling. The interface device (80) then provides an output signal to the heating and/or cooling device to establish a particular air flow rate and temperature of the system (10) to satisfy the demand for the highest load zone.

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ZONING INTERFACE SYSTEM FOR A VARIABLE SPEED HEAT PUMP

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to a control system for controlling and regulating air flow and temperature in a multiple zone heating and/or cooling system and, more particularly, to a control system for controlling and regulating air flow and temperature in a multiple zone heating and/or cooling system that uses a variable speed device, such as a heat pump, to distribute the air.

2. Discussion of the Related Art

Modern day residential heating and/or cooling systems incorporate some type of heating and/or cooling device, such as a gas furnace, heat pump, etc., that generates a hot or cold air flow and distributes it throughout the residential building through a series of duct work. In many of these systems, the heating and cooling system is separated into multiple zones where each zone is controlled by its own thermostat. A thermostat in each of the different zones regulates air flow at a desirable temperature to be delivered to the particular zone to satisfy user demand in the individual zones.

Most residential heating and cooling systems incorporate single speed devices in which air flow is delivered to the multiple zones at a single air flow rate and at an essentially constant temperature. However, it is becoming more popular to incorporate variable speed heating and/or cooling systems that operate to deliver the air flow at varying rates and temperatures so as to provide the desirable space air temperature and air quality. The variable speed devices provide a number of advantages over single speed heating and/or cooling devices. For example, with variable speed devices, the noise associated with the cycling on and off of the system is significantly reduced because the variable speed device usually operates almost continually. Further, because the variable speed devices almost continually delivers some level of air flow, they provide much better air distribution and

space humidity control. One such variable speed heating and/or cooling system is the gas engine-driven variable speed heat pump available from York International, referred to as the Triathlon System.

Although variable speed devices are known in the art that deliver varying air flow rates and temperatures in a heating and/or cooling system, these systems have not been suitably interfaced into multiple zone heating and/or cooling systems. What is needed is a system for interfacing a variable speed heating and cooling system to multiple zones. It is therefore an object of the present invention to provide such an interfacing technique.

SUMMARY OF THE INVENTION

In accordance with the teachings of the present invention, a heating and cooling system is disclosed that provides interfacing between multiple zones in the system and a variable speed heating and/or cooling device, such as a heat pump. The heating and cooling system includes a master zone control circuit including a master thermostat for controlling a master zone. The setting of the master thermostat determines whether the heating and cooling system will be in a heating or cooling mode. A plurality of auxiliary zone control circuits include separate auxiliary thermostats for controlling the auxiliary zones. Each of the master control circuit and the auxiliary control circuits provides an output signal of whether the particular zone is operating in the currently activated system mode of heating or cooling.

An interface device is responsive to all the output signals from the master control zone and the auxiliary control zones. The interface device determines which of the zones has the highest demand, meaning which zone requires the most heating or cooling depending on the setting of the thermostat for that particular zone. The interface device will then provide an output signal to the heating and/or cooling device to establish a particular heating or cooling output, i.e., air flow rate and air temperature of the system, to satisfy the demand for the highest load zone. Another output signal from the interface device turns the heating and/or cooling device off if none of the zones has a

demand. The system will remain off or remain on for a minimum period of time. If the system cannot provide a high enough speed to satisfy the highest load zone in the heating mode, then an output of the interface device initiates an auxiliary heater.

Additional objects, advantages, and features of the present invention will become apparent from the following description and appended claims taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a block diagram plan view of a known gas engine-driven variable speed heat pump including an indoor unit and an outdoor unit;

Figure 2 is a schematic block diagram of a master zone control circuit according to an embodiment of the present invention;

Figure 3 is a schematic block diagram of an auxiliary zone control circuit according to an embodiment of the present invention; and

Figure 4 is a zone interface device according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following discussion of the preferred embodiments directed to a heating and cooling control system is merely exemplary in nature and is in no way intended to limit the invention or its applications or uses. Particularly, the heating and cooling control system described below is described in conjunction with a gas engine-driven variable speed heat pump. However, the heating and cooling control system of the invention has a much wider application that includes other types of heating and/or cooling systems.

Figure 1 is a heating and cooling system 10, specifically a gas engine-driven variable speed heat pump referred to as the Triathlon variable speed heat pump available from York International. The heating and cooling system 10 includes an outdoor unit 12 and an indoor unit 14. A few of the major components of the outdoor unit 12 and the indoor unit 14 are shown for

diagrammatic purposes, with the understanding that the overall operation and configuration of the heating and cooling system 10 is well known to those skilled in the art. It is stressed, however, that the use of the variable speed heat pump illustrated is by way of a non-limiting example in that other variable speed heating and cooling systems that may include both heating and cooling, or one or the other of heating or cooling, may benefit from the invention as described below.

The outdoor unit 12 includes a gas engine 16 that burns gas to provide the power necessary to provide a flow of refrigerant for heating and cooling purposes. An auxiliary gas heater 18 is a back-up heater that supplements the gas engine 16 in the event that the gas engine 16 cannot provide the demand of the user. An indoor blower 20 within the indoor unit 14 blows air through an indoor refrigerant coil and through a heat exchanger 22 into a series of duct work (not shown) to be distributed throughout a building, such as a residential house, to provide the desirable heating or cooling. Various fluid lines 24 transfer refrigerant through and between the outdoor unit 12 and the indoor unit 14. An engine control system 28 controls the operation of the system 10, and is an electrical interface between the outdoor unit 12 and the zone control circuits discussed below.

Figure 2 is a schematic block diagram of a master zone control circuit 30 of the heating and cooling system 10 of the invention. The control circuit 30 includes a thermostat 32 that is set and regulated by a user to adjust the temperature of a master control zone to establish a comfort level in the zone suitable for the user. In the example being discussed herein, the master control zone can be a room of a residential building, such as the living area of a house. The master thermostat 32 can be any suitable thermostat for the purposes described herein, and particularly can be the triathlon thermostat used in the triathlon system discussed above, when it is applied in a single-zone application, the non-programmable Enerstat Model DSL-450, having day/night heating and cooling set points, manual day/night changeover, changeover by remote contact closure, or the programmable Enerstat Model

SHP-1. The thermostat 32 is responsive to a power signal from a 24 volt AC power source, on lines 34 and 36. Actuation of the thermostat 32 causes air flow at a suitable air flow rate through the duct work delivering the air flow to the master zone.

A switch 38 within the thermostat 32 may be closed by actuation of the thermostat 32 so as to provide a power signal on line 40 to a master zone two-position damper 42. What is meant by two-position is that the damper 42 is fully open when it is receiving power, and fully closed when it is not receiving power. If the set point, as set by the user, of the thermostat 32 is outside a predetermined temperature range around the currently sensed temperature in the master zone, as sensed by the thermostat 32, the signal on the line 40 will cause a damper motor 44 to open the damper 42 to allow air to flow at a suitable temperature into the master zone. The rate of the air flow may vary as will be discussed below. A Y1 output from the control circuit 30 provides an indication that the switch 38 is closed and that the master zone is in a demand for either heating or cooling. Note that, as described below, the master thermostat 32 determines the mode of operation (heating or cooling) for the entire system 10. Therefore, for the master zone controlled by this thermostat, the air temperature provided by the system 10 is always the correct one (hot or cold) as needed to bring the master zone space temperature to within a narrow range, near the user determined set point.

An X input into the thermostat 32 is a fault indicator which causes a service priority LED to be illuminated in the event that the heating and cooling system 10 detects a failure. A G output of the thermostat 32 is an indoor blower control that decides whether the indoor blower 20 runs continuously, or only when the system 10 is running. An O output from the thermostat 32 gives an indication of whether the main zone needs heating or cooling as determined by the setting of the thermostat 32 relative to the sensed temperature. The demand for heating and cooling of the master zone determines the heating or cooling mode for the entire system 10. For the purposes of the present invention, a signal on the O output from the

thermostat 32 indicates cooling mode, and no signal on the O output indicates heating mode. A W output from the thermostat 32 provides a signal that the main heating cannot meet the current master zone demand, and causes the system 10 to initiate the auxiliary heater 18. The X input, and the G and O outputs are connected to a control unit 46 that operates as the central controller of the heating and cooling system 10, and could be the engine control system 28. The X input, the G and O outputs are known control signals in the Triathlon system, as well as other heating and cooling systems.

The master zone control circuit 30 establishes whether the entire heating and cooling system 10 is going to be in the heating or cooling mode. Once that mode is determined, the remaining control zones are at the mercy of the selected mode. Figure 3 shows a schematic block diagram of an auxiliary zone control circuit 50 for an auxiliary zone. For example, the zone control circuit 50 may control the heating and cooling in a bedroom of the residential building. In the embodiments being described herein, there are up to five separate auxiliary zones in association with the single master zone.

The zone control circuit 50 includes a thermostat 52 being powered by 24 volts AC on lines 54 and 56. The line 56 is used if the thermostat 52 is an electronic thermostat. Typical examples of thermostats suitable for the auxiliary zones include the Enerstat Model DSL-300 including auto changeover having four temperature set points, day heating and cooling and night heating and cooling, remotely controlled day/night changeover, the Enerstat Model SK3 having 5 day programming, or the Model SHC-7 having 7 day programming.

Depending on the temperature set point selection of the thermostat 52 with respect to the sensed zone temperature, the thermostat 52 will close a cooling switch 58 or a heating switch 60. In other words, if the temperature set point is below the sensed temperature within the auxiliary zone, the thermostat 52 will close the cooling switch 58, and if the temperature set point is above the sensed temperature, then the thermostat 52 will close the heating switch 60. If the heating switch 60 is closed, a power control

signal is applied on line 62 to a normally closed terminal of a zone damper switch 64 within a zone damper assembly 66. The switch 64 applies power to a two position zone damper 68 actuated by a motor 70. The zone damper 68 is fully open when power is applied to it, or is fully closed without power. If the cooling switch 58 is closed, a power control signal is applied on line 72 to a normally open terminal of the switch 64.

The signal on line O from the master control circuit 30 is applied to a zone relay 74 within the zone damper assembly 66 on line 76. In the example described herein, a signal is applied on the line 76 when the system 10 is in the cooling mode. If no signal is applied on line 76, the zone relay 74 is not activated, and the switch 64 remains in its normally closed position, as shown, and thus is available to apply power to the zone damper 68 if the heating switch 60 is closed. However, if a signal is applied on line 76, the zone relay 74 closes the switch 66, so as to provide power to open the damper 68 when the cooling switch 58 is closed. Therefore, the zone controlled by the circuit 50 is at the mercy of the system mode selected by the master control circuit 30 in that if the master control circuit 30 selects the cooling mode by providing power at the O output, and the thermostat 52 is switched to heating by closing the switch 60, no heating is provided to the auxiliary zone controlled by the control circuit 50, but the damper 68 is maintained closed so that no cooling air is applied to this zone. Likewise, if no signal is applied at the O output, indicating a heating mode, and the user activates the thermostat 52 to close the cooling switch 58, no cooling air is applied to the zone controlled by the control circuit 50, the switch 66 stays in the normally closed position and the damper 68 is maintained closed so that heating air does not enter this zone. Alternately, the zone relay 74 can be controlled by a temperature switch (not shown) mounted in the zone supply duct, that provides power to the relay 74 when the air supply temperature is below a predetermined set point, such as 70° F, indicating the system is in the cooling mode. A Z1 output is provided on line 78 to give an indication that the zone damper motor 68 is

energized and the zone damper 68 is open, depending on which switch 58 or 60 is activated and the position of the switch 64.

Figure 3 shows a zone interface device 80 that interfaces the zone control circuits 30 and 50 with the heating and cooling system 10. The interface device 80 includes RAM memory, a power supply, and a central processing unit (CPU) suitable for the purpose described herein. In this respect, it has similar components to that of the thermostat 32, without the temperature setting and sensing components or temperature display. In one example, the zone interface device 80 includes a simple microprocessor, such as the ZILOGZ8. All the inputs to the device 80 are isolated and rectified using opto-couplers (not shown). A DC power supply circuit generates appropriate DC voltage levels for the device 80.

In this example, the interface device 80 controls interfacing between the system 10 and the master zone and five auxiliary zones. However, other numbers of zones may be applicable within the scope of the present invention. The Y1 output signal from the master zone control circuit 30 and all of the Z1-Z5 output signals from the individual auxiliary zones are applied to the device 80. Likewise, the W and 0 outputs from the master zone control circuit 30 are applied to the device 80. A 24 volt AC power signal is applied on the input lines R and B.

The zone interface device 80 determines how the variable speed heating and cooling system 10 needs to be operating to satisfy the demand of the zones. In other words, the zone interface device 80 turns the system 10 on when needed and controls the system's heating or cooling output by controlling its speed. The speed of the indoor blower 20 is controlled in a proportion to the engine speed in order to provide air flow into the duct work at a suitable rate based on user demand. If the system 10 is to be turned on as determined by the output Y1S of the device 80, then the system 10 automatically goes to some minimum speed, such as 20% of its maximum speed. An output Y2 of the device 80 determines the speed that the system 10 should be operated at above the minimum operation level. As the demand

for more heating or cooling goes up, the engine 16 will produce more hot or cold refrigerant and the blower 20 will increase its speed. In one embodiment, output Y2 is a pulse width modulated (PWM) 30VDC signal that has a one second pulse period and a duty cycle that varies from 0% to 100% in discreet steps. The duty cycle refers to the percentage of time that the system 10 is operating. An output WS determines whether auxiliary or emergency heating from the auxiliary heater 18 is necessary to satisfy the demands of the zones. All of the output signals Y1S, Y2 and WS are applied to the control unit 46 to control the operation of the system 10 as just described.

The Y1S output signal is generated when any one of the zones has a demand that is supported by the system heating or cooling mode, as selected by the master thermostat 32, i.e., any time one of the zones signals Y1, Z1, Z2, Z3, Z4, Z5 is on. The Y1S signal has a zero output to turn the system 10 off only when none of the zones has a demand. Because the zone signals Y1 or Z1-Z5 are not synchronized in time, multiple zone signals Y1 or Z1-Z5 of a relatively short duration could "add up" in a way that causes the system 10 to be on for a longer time, or conversely, could "add up" in a way that would cause the system 10 to be on for a much shorter time. This would vary the system duty cycle (system capacity) while the collective demand of the zones remains essentially the same. This effect is compensated for by controlling a minimum on and off time for the Y1S signal. The minimum on time is controlled by the zone interface device 80. If one of the zones signals Y1 or Z1-Z5 causes the Y1S output to turn on, it will stay on for a minimum time, for example six minutes. The minimum off time is already defined in the existing control unit 46. If none of the zones has demand and the Y1S turns off, the system will stay off regardless of the Y1S signal for a minimum of six minutes. The minimum and maximum on/off time of six minutes is used by way of a non-limiting example, in that other minimum and maximum on/off times may be suitable for other applications. The Y1S signal is also maintained on any time the Y2 output signal is increased above 0% PWM.

The typical cycle rate of a zone thermostat is assumed to be approximately 5 cycles per hour. At a nominal 50% zone load, i.e., when the zone heating or cooling load requires 50% of the current heating or cooling capacity available to the zone, the zone damper will be cycling six minutes open and six minutes closed (twelve minutes cycle time, five cycles/hour). With increased zone load, the on time will be longer, and with decreasing zone load, the off time will be longer. The duty cycle of the zone control signal is the proportionate time that the zone signal is on, calculated as a percentage of the total cycle time, and is an indication of the zone load. When the duty cycle of any one of the zones increases above a selected value, for example 70%, and towards 100%, it indicates that the zone demand cannot be satisfied by the system 10 running at its current speed and current heating or cooling output. Thus, the system speed, and the resulting system heating or cooling capacity, has to be gradually increased. Conversely, when all of the zone demands are satisfied, the zone duty cycles will be decreasing to below the selected value and towards 0%, and the system speed can be gradually reduced. The selected value of 70% on-time is used by way of a non-limiting example, in that other selected values may be equally applicable in different systems.

The device 80 measures the duty cycles of all the zone signals Y1 and Z1-Z5 and the highest duty cycle is used to control the system speed, i.e., the Y2 output signal. For the Triathlon system, the Y2 output signal will have a one second pulse period and a duty cycle (on-time) that varies from 0% to 100% in sixteen discreet steps of 62.5 msec. When the highest duty cycle of the zone signals Y1 and Z1-Z5 increases above the selected value, the Y2 output signal will be increased at a rate proportional to the duty cycle value. Also, any time the Y2 output signal is higher than 0%, the Y1S output signal will be kept continuously on. This assures a correct sequence of the system control signals. When the highest duty cycle of the zone signals Y1 and Z1-Z5 decreases below the selected value, the Y2 output signal will be decreased at a rate proportional to the duty cycle value.

The zone interface device 80 implements an integrating system speed control that adjusts system capacity to maintain the zone with the highest load at a selected duty cycle value, i.e., a duty cycle set point. This control strategy is given by the following equations:

$$D_n = \left(\frac{T_{n(ON)}}{T_{n(ON)} + T_{n(OFF)}}\right)100 \qquad (1)$$

$$D_{MAX} = MAX(D_n) \qquad (2)$$

where,

D_n is the duty cycle of a particular nth zone, i.e., the percent of time a particular nth zone damper is open;

T_n is the on or off time of the nth zone; and

D_{MAX} is the highest duty cycle, i.e., the duty cycle of the highest load zone.

Therefore, by equations (1) and (2), the interface device 80 first determines the percent of time each zone is on, i.e., its duty cycle, and then determines which one of those duty cycles is the highest so as to determine which zone as the highest load (D_{MAX}).

System speed (on-time of the Y2 output signal) in the next sampling period is calculated from the current system speed as:

$$Y2_{t+x} = Y2_t + \left(\frac{D_{MAX} - D_{SP1}}{100}\right)k_1 \qquad (3)$$

where,

t+x is the time instant of the next sampling period;

t is the time instant of the current sampling period;

k_1 is an integration rate for Y2 in milliseconds;

D_{SP1} is a predetermined highest-load zone duty cycle set point; and
D_{MAX} is the duty cycle of the highest-load zone.

Therefore, equation (3) gives the Y2 output for consecutive sample periods so that the system 10 knows whether to increase or decrease its speed to satisfy the highest load zone. The value of the Y2 output signal is limited to be always higher than 0 and lower than a maximum of 1000 msec.

The above equation parameters can be adjusted to fit a particular application so as to achieve a stable system capacity control. For example, x can be 60 to 300 seconds and k_1 would typically be a time value that represents one Y2 output step (62.5 msec) or a fraction of one step. The duty cycle set point D_{SP1} can be set between 70% to 90% where the lower values will cause the system to cycle less frequently, and to react faster to sudden increases in zone load. Higher values will provide a better energy efficiency where the system turns off more often and runs at lower speeds.

As the duty cycle of the highest-load zone D_{MAX} deviates from the set point D_{SP1}, the system speed is adjusted and the changed system capacity causes a change in the duty cycle that brings D_{MAX} back to the set point D_{SP1}. An increasing load in the highest-load zone may cause the system speed to increase to maximum. When the system 10 is operating at its maximum speed in the heating mode, i.e., Y2=100%, it is an indication that supplemental heating from the auxiliary heater 18 is needed to satisfy the heating demand. The system auxiliary heating control signal WS will be turned on by the zone interface device 80 and cycled at an increasing duty cycle. In one example, the pulse period of the WS output signal is fixed at 15 minutes (4 cycles/hour), and the duty cycle is adjusted from 0% to 100% (0-15 minutes) in a similar way as for the Y2 output signal. Further, any time the WS output signal on-time is higher than 0%, the Y2 output signal will be kept continuously at 100%.

The on-time length of the WS output signal in the next sampling period is calculated from the current on-time WS output signal as:

$$WS_{t+x} = WS_t + \left(\frac{D_{MAX} - D_{SP2}}{100}\right)k_2 \tag{4}$$

where,

k_2 is the integration rate for WS in minutes;

D_{SP2} is a predetermined highest-load zone duty cycle set point; and

D_{MAX} is the duty cycle of the highest-load zone.

The value of the WS output signal is limited to always be higher than zero and lower than the maximum of 15 minutes. The constant k_2 would typically be 0.5 to 2 minutes. The duty cycle set point D_{SP2} can be set at 95% (for example) and must always be higher than the set point D_{SP1} that is used for system speed control. Note that the possibility of a "windup," inherent in simple integrating control, does not present a problem here because each zone is controlled accurately by its own thermostat regardless of system capacity.

Emergency heat mode is selected by the master thermostat 32. This mode would be used only in a case of a system malfunction, in order to allow the master thermostat 32 to bypass most of the system controls and control the auxiliary heater with its WS output signal. Any time the master zone W signal turns on, it causes the WS output signal to go on as well. The space temperature control in this mode is performed by the master thermostat 32 per its set point. All other zones are at the same time trying to control zone temperatures to their respective zone set points in normal fashion and can, if the system would be functioning normally, control system on/off and system speed and auxiliary heat also, in addition to the direct auxiliary heat control by the master thermostat 32.

The foregoing discussion discloses and describes merely exemplary embodiments of the present invention. One skilled in the art will readily recognize from such discussion, and from the accompanying drawings and claims, that various changes, modifications and variations can be made

therein without departing from the spirit and scope of the invention as defined in the following claims.

CLAIMS

What is Claimed is:

1. A heating and/or cooling system comprising:

air flow means for providing air flow at a variable air flow rate and temperature;

a master zone control circuit, said master zone control circuit providing a demand output signal of whether the master zone control circuit has a demand for heating or cooling;

at least one auxiliary zone control circuit, said at least one auxiliary zone control circuit providing a demand output signal of whether the auxiliary zone control circuit has a demand for heating or cooling; and

zone interface means for controlling the air flow rate of the air flow means, said zone interface means being responsive to the demand output signals from the master zone control circuit and the at least one auxiliary zone control circuit.

2. The system according to Claim 1 wherein the zone interface means determines the air flow rate and temperature based on which of the master zone control circuit or the at least one auxiliary zone control circuit has the greatest demand for heating or cooling.

3. The system according to Claim 2 wherein the zone interface means determines the zone control circuit with the greatest demand by monitoring the proportionate time that each of the demand output signals of the zone circuits are on so as to determine which zone circuit has the highest duty cycle.

4. The system according to Claim 3 wherein the zone interface means attempts to maintain the zone circuit with the highest duty cycle at a predetermined set duty cycle.

5. The system according to Claim 1 wherein the zone interface means utilizes an integrating system speed control to adjust the air flow rate and temperature of the air flow means to maintain the zone control circuit having the greatest demand at a selected duty cycle value.

6. The system according to Claim 1 wherein the at least one auxiliary zone is a plurality of auxiliary zone control circuits each providing a demand output signal to the zone interface means.

7. The system according to Claim 1 wherein the master zone control circuit includes a heating or cooling mode output signal providing an indication of whether the master zone control circuit is in a heating or cooling mode, said at least one auxiliary zone control circuit and said zone interface means both being responsive to the heating or cooling mode output signal.

8. The system according to Claim 1 wherein the air flow means is a variable speed heat pump.

9. The system according to Claim 1 wherein the system is a residential heating and cooling system.

10. The system according to Claim 1 wherein the zone interface means includes an auxiliary heater output signal that actuates an auxiliary heater so as to provide auxiliary heating in the event that a main heating system cannot provide a zone load.

11. The system according to Claim 1 wherein the at least one auxiliary zone control circuit includes a thermostat having a heating switch and a cooling switch.

12. The system according to Claim 1 wherein the zone interface means includes a system on or off output signal, said air flow means being responsive to the on or off output signal so as to provide air flow based on the signal, said on or off output signal based on whether the master zone control circuit or at least one auxiliary zone control circuit have a demand for heating or cooling.

13. The system according to Claim 12 wherein the on or off output signal is maintained on or off for a predetermined minimum time.

14. A heating and/or cooling system comprising:

a variable speed heating and/or cooling device, said heating and/or cooling device providing air flow at a variable air flow rate and temperature;

a master zone control circuit including a master zone thermostat, said master zone control circuit providing a demand output signal of whether the master zone control circuit has a demand for heating or cooling based on the setting of the master thermostat, said master zone control circuit also providing a heating or cooling mode output signal indicative of whether the master zone control circuit is in a heating or cooling mode;

a plurality of auxiliary zone control circuits each including an auxiliary thermostat, each of the auxiliary zone control circuits providing a demand output signal of whether the auxiliary zone control circuit has a demand for heating or cooling based on the setting of the auxiliary thermostat, each of the auxiliary zone control circuits being responsive to the heating or cooling mode output signal from the master zone control circuit; and

zone interface means for controlling the air flow rate and temperature of the heating and/or cooling device, said zone interface means being responsive to the demand output signals from the master zone control circuit and the plurality of auxiliary zone control circuits and the heating or cooling mode output signal from the master zone control circuit, said zone interface means utilizing an integrating system speed control to adjust the air flow rate and temperature of the heating and/or cooling device to maintain the zone control circuit having the highest demand at a selected duty cycle value.

15. The system according to Claim 14 wherein the zone interface means determines the zone control circuit with the greatest demand by monitoring the proportionate time that each of the demand output signals of the zone circuits are on so as to determine which zone circuit has the highest duty cycle.

16. The system according to Claim 14 wherein the air heating and/or cooling device is a variable speed heat pump.

17. The system according to Claim 14 wherein the zone interface means includes an auxiliary heater output signal that actuates an auxiliary heater so as to provide auxiliary heating in the event that a main heating system cannot provide a zone load.

18. The system according to Claim 14 wherein the zone interface means includes a system on or off output signal, said heating and/or cooling device being responsive to the on or off output signal so as to provide air flow based on the signal, said on or off output signal based on whether the master zone control circuit and the plurality of auxiliary zone control circuits have a demand for heating or cooling, said on or off output signal being maintained on or off for a predetermined minimum and maximum period of time.

19. A method of providing heating and/or cooling over multiple zones, said method comprising the steps of:

providing an air flow device for providing air flow at a variable air flow rate and temperature;

controlling a master zone including determining whether the master zone has a demand for heating or cooling;

controlling at least one auxiliary zone including determining whether the at least one auxiliary zone has a demand for heating or cooling;

interfacing the air flow device with the master zone and the at least one auxiliary zone to determine which of the zones has the greatest demand for heating or cooling; and

controlling the air flow rate and temperature of the air device based on which zone has the highest demand for heating or cooling.

20. The method according to Claim 19 wherein the step of interfacing the air flow device with the zones includes utilizing an integrating system speed control scheme to monitor the proportionate time that each of the zones has a demand for heating or cooling.

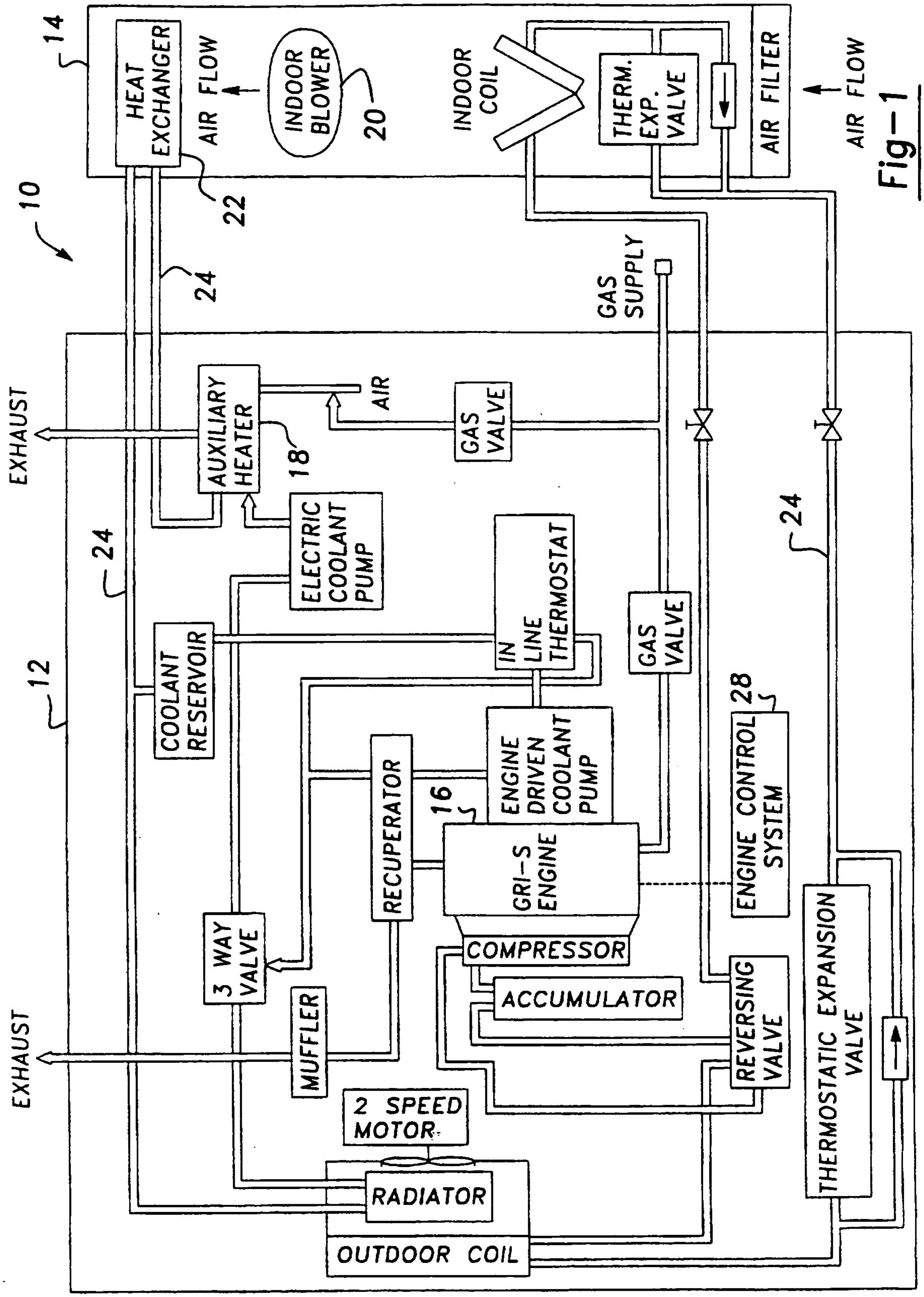
14
HEAT EXCHANGER
AIR FLOW
INDOOR BLOWER
20
INDOOR COIL
THERM. EXP. VALVE
AIR FILTER
AIR FLOW
22
10
24
GAS SUPPLY
EXHAUST
AUXILIARY HEATER
18
AIR
GAS VALVE
ELECTRIC COOLANT PUMP
IN LINE THERMOSTAT
24
COOLANT RESERVOIR
GAS VALVE
24
12
28
ENGINE CONTROL SYSTEM
RECUPERATOR
ENGINE DRIVEN COOLANT PUMP
16
GRI-S ENGINE
COMPRESSOR
ACCUMULATOR
3 WAY VALVE
REVERSING VALVE
THERMOSTATIC EXPANSION VALVE
EXHAUST
MUFFLER
2 SPEED MOTOR
RADIATOR
OUTDOOR COIL

Fig-1

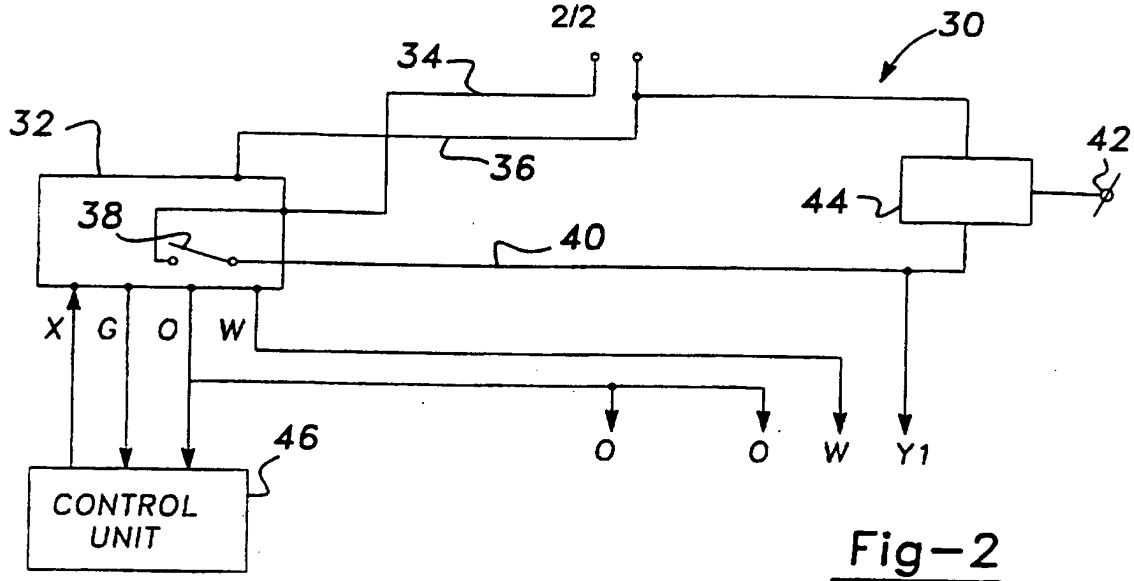

Fig-2

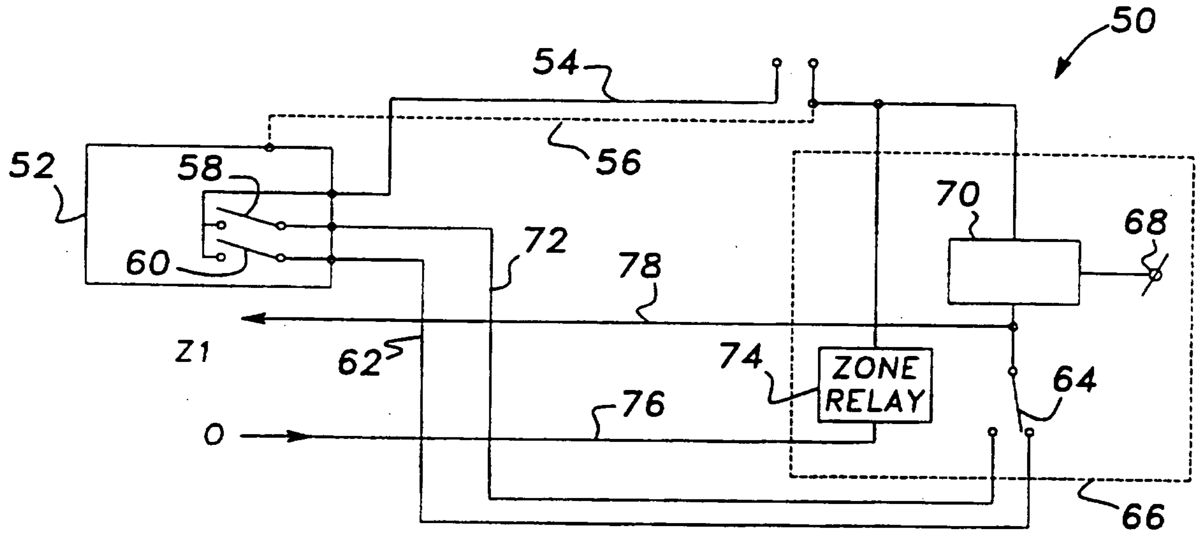

Fig-3

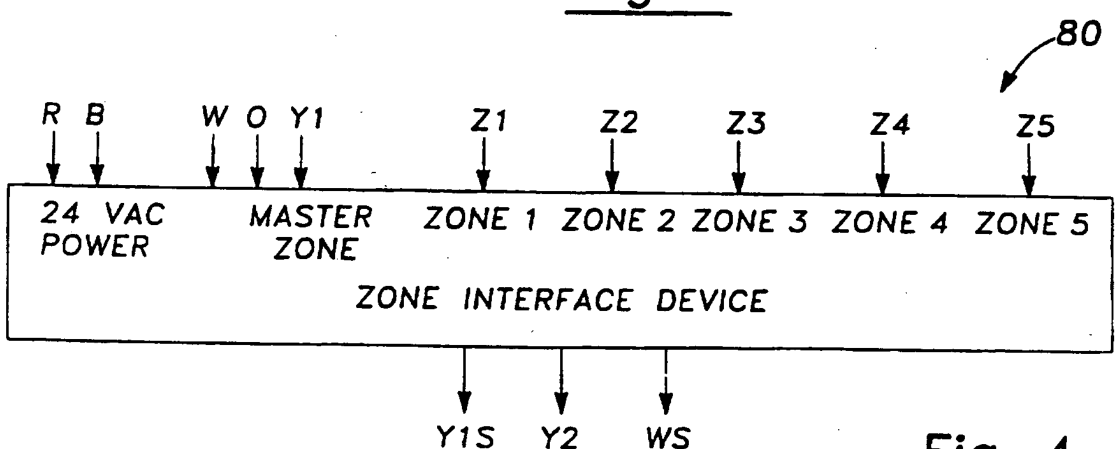

Fig-4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/11067

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :F25B 29/00
US CL :165/217, 240; 236/1B, 1C, 49.3
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 165/217, 240; 236/1B, 1C, 49.3

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ---- Y	US 4,932,466 A (FOSTER) 12 JUNE 1990, ENTIRE DOCUMENT.	1, 6, 7, 9 AND 11-13 ---------------- 2-5, 8, 10, 19 AND 20
Y	US 5,024,265 A (BUCHHOLZ ET AL.) 18 JUNE 1991, ENTIRE DOCUMENT.	2-5, 19 AND 20
Y	US 4,716,957 A (THOMPSON ET AL.) 05 JANUARY 1988, ENTIRE DOCUMENT.	8, 10

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
02 SEPTEMBER 1997	31 OCT 1997

Name and mailing address of the ISA/US	Authorized officer
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